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ABSTRACT

The Zimbabwe Secondary School Science Project (ZIM-SCI) developed student study guides, corresponding teaching guides, and science kits for a low-cost science course which could be taught during the first 2 years of secondary school without the aid of qualified teachers and conventional laboratories. This teaching guide, designed to be read in conjunction with the related student guide, includes instructional strategies, lists of required materials, laboratory procedures, and other information for activities and experiments in a three-part unit in which students: (1) examine the nature, properties, and potability of water; (2) mix substances which produce solutions and suspensions; and (3) examine the solubility of substances and the rate at which they dissolve, prepare saturated solutions, and separate liquid mixtures. Each section in this guide corresponds to a given section in the student study guide. (JN)

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ZIM–SCI

ZIMBABWE SECONDARY SCHOOL SCIENCE PROJECT

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SE043839

TEACHER'S GUIDE UNIT D

What do you know about water?

UNIVERSITY OF ZIMBABWE
AND MINISTRY OF EDUCATION AND CULTURE

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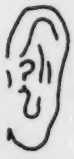
July, 1981

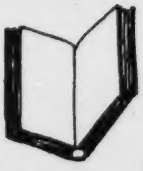
The following symbols will be used to indicate the points in the lesson at which teacher activity is particularly important. These symbols also appear at the corresponding points in the pupil study guides.

Practical work. The necessary instructions for each experiment will be given to you when you see this symbol.

Written exercises for the pupils. If possible these should be put on the blackboard before practical work begins so that the pupils can see what to look for.



Teacher information. The pupils will need extra guidance at these points. The information they will need from you is given where you see this symbol.



This symbol appears at a point where it is necessary for pupils to think over what they have done in the past few lessons. Set aside a period for this review activity. Encourage the pupils to read over their notes and the study guide section which they have just covered. It may be helpful to ask them to write a summary too.

The following symbols which appear only in the Teacher's Guide are used to indicate important points for you the teacher.

Take note of an important point.

This symbol indicates a preparation of apparatus which should be done well ahead of time. Please read these notes carefully and carry out the instructions well in advance.

We have placed this symbol next to experiments where we feel there may be a possible danger. Please read the section carefully so that you know about the particular danger in that experiment. It would also be wise to refresh your memory on the appropriate safety or first-aid procedures described in the Zim-Sci Handbook.

TEACHER'S GUIDE

UNIT D : WHAT DO YOU KNOW ABOUT WATER

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AIMS UNIT D

(EXTRACTED FROM SYLLABUS)

WHAT DO YOU KNOW ABOUT WATER

At the end of this Unit pupils will be able to :-

1. Name the states of water and describe how to change water from one form to another.

2. Explain the changes of state in terms of particles and energy.

3. Explain the formation of clouds, mist and occurrence of rainfall.

4. Design experiments and state how to purefy impure water by filtration, distillation and how to separate alcohol-water mixture by fractional distillation.

5. Design experiments on solubility and determine the factors that affect solubility.

6. Explain solubility in Kinetic terms.

7. Identify natural crystals and design experiments in the laboratory to grow crystals of their own.

TEACHER'S GUIDE

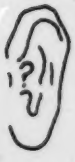
This unit is in three related parts. In part one pupils look at natural water - where it comes from, what it contains and how it is made safe to drink.

In part two pupils mix substances which produce solutions and suspensions. In part three your pupils will look at the solubility of substances and how fast they dissolve. Pupils will make saturated solutions and produce crystals from the solutions.

The last section deals with the separation of liquid mixtures.

PART 1

Page 4 Daily use of Water



Ask the pupils how much water they use daily for washing themselves, for washing their clothes and for watering the garden. Then let them compare the amount of water they use with that which Musa uses on page 4 of the study guide.

Page 6

EXPERIMENT 1 Drying Wet Papers

Each pair of pupils will need:

3 filter papers

3 paper clips

Help them to fix the clips onto the filter papers. They must do this properly or else the papers will fall. Then they wet the lower halves of the filter papers. They will each hang one of their papers in a different place, so fix a long thread at each place, e.g. the back of the classroom, under the tree, out in the sun, for them to hang the papers on.
Remind them to put their names or initials on the papers so that they will be able to identify them.
As they wait for the papers to dry, they should wet their hands with water and wave them in the air as instructed in their study guide. This little experiment will help to reinforce the idea that moving air aids the evaporation of water.

If you think it necessary, they can use the clock to estimate the time each paper takes to dry. After the experiment, ask them to suggest where they would want to dry their clothes. It would also be worth while if you asked them about conditions in which things take a long time to dry.

The pupils should find that the best drying conditions are in moving air in sunlight. Worst conditions are in still air in shade.

Page 7

EXPERIMENT 2 Breathing on a boiling tin

The main idea of this experiment is for pupils to see that a vapour condenses into a liquid when cooled. Write Exercise 1 on the blackboard for them to answer in their exercise books.

Exercise 1: Explain how the water got onto the tin from your breath.

Answer: The answer may be on these lines:

"The air which I breathed out was warm and saturated with water vapour from my lungs. When the air got onto the cold surface of the tin it was cooled. Water vapour from the saturated air condensed as droplets of water on the tin".

It is important that they point out that the air from their lungs is warm and saturated with water vapour.

A cold surface is required for condensation to happen. In nature, rain is formed when air saturated with water vapour is cooled. Discuss with them again the formation of clouds and rain. In your discussion talk about the water cycle and it will help you if you draw this cycle on the blackboard.

Some information on the water cycle is found in 'Science for the 70's', Book 1, page 74. After the discussion they should answer Exercise 2.

Exercise 2: Draw a diagram to show the water cycle.

Answer: They should draw a diagram similar to that you used in the discussion. They should label the air saturated with water vapour, the clouds and rain.

Page 9

EXPERIMENT 3 Finding out what makes water dirty

For this experiment the pupils will need:

some clean water
some dirty water

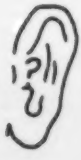
You will need to make some dirty water for this experiment. Each pair will need about $20cm^3$ of dirty water, so altogether your class will need about $500cm^3$ of dirty water. There will be enough of this water if you fill 2 flasks with water. Add some soil to each and swirl the flasks and there is the dirty water!

Before the pupils start doing the experiment draw the following table on the blackboard and ask them to copy it into their exercise books.

Type of water	Height of water	Appearance of filter paper
dirty water		
clean water		
filtered water		

If the water is dirty, less is needed to hide the word 'clean'. The height of the clean water will be greater than that of the dirty water.

The pupils will find on their filter paper a lot of solid material. This will depend on the nature of the soil used in making the water. Generally, these will be small rock particles, pieces of grass, leaves, etc.



Filtration is one way of cleaning dirty water. However the method is not suitable for cleaning water for a lot of people. Ask them to suggest a better method of cleaning water for a lot of people.

Take the pupils' suggestions seriously and perhaps even try out one or two! Experiment 4 is a model of one way in which large volumes of water can be cleaned.

Page 1:1

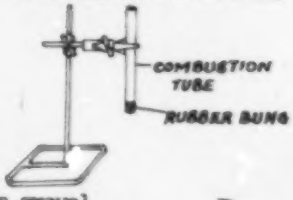
EXPERIMENT 4 Cleaning a lot of water

For this demonstration experiment you will need:'

- 2 conical flasks, 1 empty and 1 full of dirty water (made as in Experiment 3)
- a glass tube (combustion tube in your kit. This tube is about 30cm long and about 2cm in diameter)
- a retort stand
- clamp and bosshead
- some clean fine river sand) collect in advance and
- some clean gravel) clean several times
-) with water
- a rubber bung with one hole

When all these are ready you can then make your filtration column. Your pupils will benefit more if you make the column in front of them. These are the steps you can follow:

1. Clamp the glass tube and fix the rubber bung at the bottom end.



2. Put 5cm of clean gravel into the tube, then 10cm of clean fine sand.

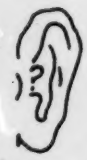
3. Pour about half of the dirty water into the tube using a funnel. Use the second flask to collect the water coming out of the column.

Please turn over

8

4. Wait until the water stops dripping from the tube. Stand the flasks containing dirty water and filtered water together and let the pupils compare the two types of water.

Ask the pupils to suggest why you put gravel at the bottom of the column and sand at the top. If you are not sure of the reason, the explanation is that the fine sand filters off the suspended solid material, just like a filter paper does. The gravel prevents the fine sand from being carried down with the flowing water. The gravel also allows the filtered water to flow easily.

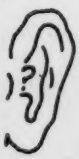


After the experiment discuss the suitability of this method for making water clean. They will have seen that even this method will not remove small dirt pieces. It will also not remove the very small harmful organisms often found in water. Refer to the organisms they saw in Unit A2. Tell them about the chemical chlorine. Chlorine is a green gas which is bubbled through water for use in towns. It kills harmful organisms. At this point give your pupils a lesson period to revise the work that has been covered so far.

Page 13

EXPERIMENT 5 Taking a Closer Look at Water

In this experiment the pupils discover that air is a substance found in water. The experiment is simple. They only need to warm the water and air bubbles come out. Discuss with the pupils the importance of this air for organisms, such as fish, found in water. They need this air to live. Ask them if air is the only substance dissolved in water. They should suggest how they can investigate this before they look at Experiment 6.



Page 14

EXPERIMENT 6 Finding out if anything is left when water evaporates

Each pair of pupils will need

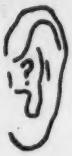
a dropper
3 microscope slides
handlens
water from a well, river, borehole or tap water. (Please make sure the water is ready before the experiment.) The pupils must have water from at least two sources so that they can compare the residues.

In instruction No. 6, the plastic bottle does not need to be completely dry. Warn the pupils against holding the slide too near the flame or else it will break. They must put the drop of water sample near one end of the slide as shown in the study guide. Remind them to remove the slide as soon as all the water has evaporated. Ask them to look at the residue using their hand lenses. Then write Exercise 4 on the blackboard for them to answer.

Exercise 4:

(a) Which slide had most residue?
(b) Which slide had least residue?
(c) Describe the colour of the residues of all the water samples you used.

Answer: The amount of residue will depend on the source of water samples they used. The colour will depend on the nature of the water sample, but for most of the residues the colour will most probably be a dirty white.

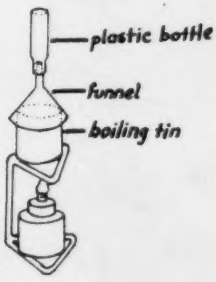


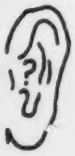
These chemical substances dissolve in the water as it flows through the ground. Some of them dissolve as the water flows over the rocks in rivers.

Pages 15, 16, 17

EXPERIMENT 7 Holding a plastic cup in steam

This experiment is an introduction to purifying liquids by distillation. Already your pupils know about evaporation and condensation. They know that condensation involves cooling a vapour. They can now make use of this knowledge to make pure water (distilled water). Discuss how they can make pure water. Give them a free hand here to devise their own methods of collecting this water. You will have to supervise your class closely. However, do not waste too much time on methods that seem way off. If no good ideas are forthcoming suggest to them this possible arrangement.

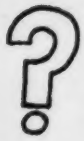




Ask them how they can improve this arrangement to collect enough water to fill a plastic bottle. Give them time to think. When they have collected enough water they should find out if the water is really pure. Do not lead straight away into evaporating the water as in Experiment 6. Give them time to think of the solution to the problem themselves.

Spend a lesson on revision at this point.

HOW MUCH DO YOU KNOW?



These are the words to be used in filling in the blanks in the sentences.

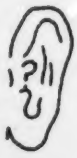
1. Evaporate
2. Hot, dry, moving (any one of the three words will be correct).
3. Cold, moist, 'not moving' (any one will do).
4. Saturated
5. Boiling it (cleaning is not quite correct because clean water will not necessarily be safe to drink).
6. Filtration
7. Condensed
8. Distillation
9. Distilled.

PART 2

MIXTURES

Your pupils have some idea of a mixture from what they did in Unit C1. They also looked at air and other things dissolved in water in Experiments 5 and 6 of this Unit. The air was separated from the water by just warming the water. The other substances found in water were separated from it by evaporating the water.

Remind the pupils about the mixtures they met in Unit C1. Go through the list of properties of mixtures on page 23 of the study guide for Unit C1. It will be better if you wrote the list of properties on the blackboard.



Using this list they must choose examples of mixtures in addition to those they met in Unit C1. Draw a table like this one on the blackboard.

Mixture	Things found in it	How can the mixture be separated

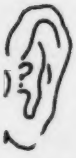
It will be more interesting if you asked them to fill in the table on the blackboard in turns with their suggestions for mixtures. After filling in the table return to the study guide to introduce the words used in describing mixtures; words like: solute, solvent, solution, suspension. At this point we have taken the opportunity to bring out the difference between melting and dissolving since these two terms are often confused.

Read to the end of page 19 in the study guide with the children so they understand dissolving, and then make a short list of substances which dissolve in water. This exercise helps to familiarise the pupils with the concept and leads into Experiments 8 and 9. Put this table on the board for the pupils to copy but do not fill in the observations in the second and third columns. These are just for your information and assistance in marking. The pupils should make their own observations.

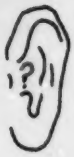
Page 20

EXPERIMENT 8 Dissolving substances in water

Substance	Appearance of mixture	Dissolve/does not
Sodium Carbonate	Should be colourless but may be cloudy if the water contains calcium	Dissolves, but may form a cloudy mixture of calcium carbonate if the water contains calcium
Calcium Chloride	Colourless	Dissolves
Sulphur	A yellow suspension of sulphur in water	Does not dissolve
Naphthalene	Suspension of naphthalene in water	Does not dissolve



Discuss with them why some substances dissolve in water and others do not. This is a difficult question at this stage. It will be sufficient if you tell them that particles of some substances can be separated from each other by the water and others can't be separated. Some substances which do not dissolve in water do in fact dissolve in other substances.



Ask the pupils what other liquids they can think of from everyday life which might dissolve these substances, e.g. petrol, paraffin, milk, methylated spirits. Tell them we are investigating the properties of methylated spirits as a solvent.

Page 21

EXPERIMENT 9 Dissolving things in Methylated Spirits

Make sure there are no burner flames as they do this experiment, as methylated spirits is inflammable.

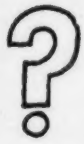
Give each pair of pupils a spatula full of the substances they used in Experiment 8 to try to dissolve in methylated spirits. Give each pair about half a plastic bottle of methylated spirits for each substance they try. Please collect the mixtures into a conical flask. Pour off the clear methylated spirits into a mazoe bottle leaving the undissolved residue behind after the lesson. You can keep this methylated spirits for filling burners.

Here is a completed table for this experiment. Once again do not give the pupils the observations written in columns 2 and 3.

Substance	Appearance of mixture	Dissolves/does not
Sodium Carbonate	Sodium carbonate just settles on the bottom of the plastic bottle	Does not dissolve
Calcium Chloride	The pieces of calcium chloride settle at the bottom of the bottle	Does not dissolve
Sulphur	A yellow suspension of sulphur formed	Does not dissolve
Naphthalene	Some of the naph-thalene dissappears, the rest settles at the bottom	Dissolves, but not very much

Discuss with them other solvents and what solutes they dissolve. Use the information in 'Science for the 70's', Book I, page 83.

HOW MUCH DO YOU KNOW?



The words for filling in the blank spaces are:

1. Solution
2. Solute
3. Solvent
4. Solution
5. Suspension

Note: There is an error in the study guide, question 5. The question should read: "A mixture of substances that does not form a clear solution is called a ———— ."

PART 3

Page 22

EXPERIMENT 10 To investigate how much Copper Sulphate dissolves in $10cm^3$ of cold water

Each pair of pupils will need 4 spatulas full of powdered copper sulphate (please grind the copper sulphate in a fine powder for it to dissolve quickly - use a smooth stone for grinding the copper sulphate).

N.B.

Make sure they keep the cold saturated solution. They will need it for Experiment 11.

Exercise 5:

Draw the following table for the pupils to copy into their notebooks. They should complete the first part after dissolving the copper sulphate in cold water. They will complete the second part after doing Experiment 11.

	Number of spatulas full added	Dissolves/ no longer dissolves
Cold Water	1	Dissolves
	2	
	etc	
Hot Water		
Total		

The idea is to make the pupils see that there is a limit to the amount of copper culphate which will dissolve in $10cm^3$ of cold water. They should keep the saturated solution for use in the next experiment.

Warn the pupils to wash their hands well as copper sulphate is poisonous and can be dangerous if it gets into their eyes. (In fact it is acidic.)

Page 23

EXPERIMENT 11 Dissolving some Copper Sulphate in Hot Water

Each pair will need about 4 more spatulas full of copper sulphate to dissolve in hot water. They should record their results in the second part of the table. The idea is that the same amount of water will dissolve more copper sulphate when hot than when cold. Generally, a hot solvent dissolves more solute than a cold one, though there are exceptions, like sodium carbonate which is dissolved less in boiling water than in water at 50°C.

After the experiment collect all the saturated copper sulphate solution into a flask. It will be needed in Experiment 14.

Page 24

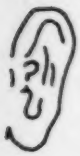
EXPERIMENT 12 Dissolving Salt in 10cm^3 of Cold Water

Each pair will need 4 spatulas full of Sodium Chloride.

Exercise 6:

Draw the table below for the pupils to complete as they do the Experiment.

Number of spatulas of salt	Dissolves/no longer dissolves



The idea is for the pupils to notice that the same amount of solvent requires different amounts of different solutes to form a saturated solution. Explain to them that the reason for this is that in some solid substances particles are held more strongly than in others. So, the water is able to pull the particles apart more readily in some substances than in others. It is not necessary to go into further detail at this stage.

Though a spatula full is a convenient unit to use in this experiment pupils should be aware that it is not an accurate unit. Often solubility is measured in grams of solute which will dissolve in 100 grams of solvent at a particular temperature.

Page 25

EXPERIMENT 13 Stirring some Sugar in Water

Each pair of pupils requires 2 spatulas full of sugar. Remind them to use clean plastic bottles and spatulas since they are required to taste the sugar solutions. The idea is that the sugar in the stirred mixture should dissolve faster than that in an unstirred one. They should suggest what happens to the sugar particles as the mixture is stirred. They will have some idea because they stirred dyestuff (and made a model of it) in Unit C1.

Ask them to suggest other ways of making substances dissolve more quickly. From what they have done so far, they should be able to give you correct answers. Grinding the solute is one answer. Dissolving the solute in a hot solvent is another.

Write Exercise 7 on the blackboard for them to answer in their books.

Exercise 7: Write a full report of the experiment in your exercise book.

The report must contain:

(a) what you did in the experiment;
(b) what you saw;
(c) what you learned from the experiment.

The most important thing here is the conclusion they came to in (c). This should be that stirring a mixture makes the solute dissolve faster. It will also be correct if they simply say that stirring the mixture makes the sugar dissolve faster, since this is what happened in the experiment.

After this exercise let the pupils spend some time revising what they have done so far.

Pages 26, 27

EXPERIMENT 14 Looking at a saturated solution

Each pair of pupils will require:

4 spatulas full of alum

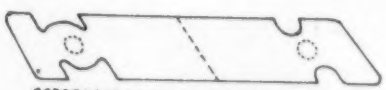
a micromount

They should dissolve all the alum in the hot water. The usual rules do not apply when judging whether an alum solution is saturated. This hot solution will be saturated even if no alum crystals are left in the solution.

Show the pupils how to prepare a micromount.

Below are the instructions on how to do this. Please read these carefully and practise how to mount a specimen before the lesson.

1. Remove the two discs of cardboard from cardboard holder by pushing them with your finger.



CARDBOARD HOLDER BEFORE FOLDING

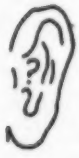
There are diagrams on the sheet accompanying the micromount

2. Then fold the cardboard holder into two along the line in the middle. All the letters must be on the outside.

3. Now press the two halves of the cardboard holder together. They should stick together.
4. Slide the transparent acetate folder into the cardboard holder.

Your pupils must place the drop of solution ON the acetate folder (not squashed inside the folder)..

They should use the stirring end of the spatula for picking up a drop of the solution. Make sure they do this while the solution is hot. When they have finished looking at the drops, put a drop of this solution on a microscope slide and show them what happens in the drop using your microscope.



While they are looking at their alum crystals, heat the copper sulphate solution you kept from Experiment 11. As soon as all the crystals have dissolved, give them this solution (they should collect this in the other plastic bottle), to repeat what they did with the alum solution. They should then answer Exercise 8.

Exercise 8:

(a) draw the most common shape of one crystal of alum.
(b) draw the most common shape of one crystal of copper sulphate.

At this stage your pupils should be able to tell you the general characteristics of crystals. The alum crystals are different in shape from those of copper sulphate because the particles of these two substances are different in size and they are arranged differently in the crystal.

Write Exercise 9 on the blackboard for the pupils to answer in their exercise books.

Exercise 9:

(a) Describe what you saw happening in the drop of alum solution you looked at under the bioviewer.

(b) What happened in the solutions of alum and copper sulphate which cooled slowly in the bottles?

(c) Were the crystals in the bottles larger or smaller than those which formed on the micromount?

(d) Cooling a hot saturated solution quickly produces ---------- crystals.

(e) Cooling a hot saturated solution slowly produces ---------- crystals.

Answers:

These are the possible answers:

(a) Small alum crystals formed on the micromount.

(b) Large crystals formed and settled at the bottom of the bottles.

(c) The crystals which formed in the bottles were larger than those which formed on the micromount.

(d) Cooling a hot saturated solution quickly produces small crystals.

(e) Cooling a hot saturated solution slowly produces large crystals.

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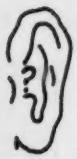
EXPERIMENT 15 Producing large crystals

They will need a small crystal to grow into a large one.

Make sure they choose good crystals (regular shape with complete faces). They need a strongly saturated alum solution or else the crystal will not grow, so give each pair an extra spatula full of alum to put into their bottles. The bottle should be half full of solution. Give the pupils the biostrip entitled "Minerals and Crystals" to finish off this section of the unit.



Encourage them to collect some rock crystals they might find interesting.

MIXTURES OF LIQUIDS

In Unit C2, you made a mixture of methylated spirits and water. There was some indication that a solution was forming because the particles of one liquid moved into the spaces between particles of the other.

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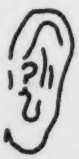
EXPERIMENT 16 Mixing Water with Glycerine

Give each pair of pupils 2ml of glycerine. In some previous experiments they dissolved solid solutes in liquid solvents. In this experiment a liquid solvent dissolves a liquid solute. Glycerine is very soluble in water.

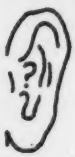


Tell them about other liquid mixtures. These are a few with which the pupils may be familiar:

paraffin dissolves oil
petrol dissolves oil
benzine dissolves oil

You can add more to this short list.

From the work they did in Unit C1 the pupils know how to separate mixtures of solids and liquids. In the following experiment they will try to separate a mixture of water and methylated spirits. Each pair of pupils will require a plastic bottle full of the mixture. So make 500ml of the mixture by mixing a flask full of methylated spirits with a flask full of water. Mix them in a mazoe bottle. Give them time to try out their methods. They will need some help here but try not to give them a lot of help! If their methods are way off, suggest this arrangement.



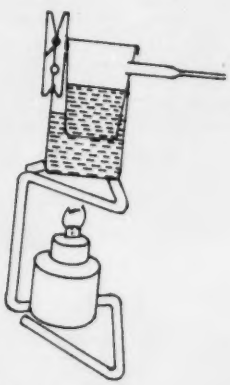
They will need:

their plastic cup with its lid
a short glass tube from the dropper
a peg
boiling tin
stand and burner

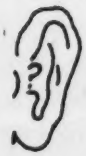
Show them how to assemble the separating apparatus. Make sure all the pupils watch while you do this. Ask for a plastic cup from one group.

1. Heat the wide end of the dropper in a burner flame.
2. When this is hot, push it through the plastic cup quickly, just below the level of the lid. Remove the hot glass tube quickly to avoid making a hole too large to hold the glass tube tightly.

When you have done this ask them to go through the same process with their plastic caps. After they have done this they should arrange the apparatus as shown.



With this arrangement they should be able to collect a few drops of methylated spirits. Let them try to burn the methylated spirits on their evaporating dish. It should burn. If they try to burn the mixture it will not burn.



Ask them to suggest why the water did not distill over together with the methylated spirits. As you know methylated spirits forms a vapour much more easily than water and therefore boils at a lower temperature than water. It distils over first. Tell them that this separation of liquids can only be done if the mixture contains liquids which boil at different temperatures. You may discuss the importance of the process in industry, like in refining oil.

After the discussion they should answer Exercise 10 in their books.

Exercise 10:

Draw in your exercise books a diagram of the apparatus you used in the above experiment. The diagram should look more or less like that in your guide.